Wireless Access Technology for Smart Highway

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ABTSTRACT

Smart Highway project will open new paradigm which provides more reliable, safe and convenient highway than current highway system in Korea. We introduce basic service requirements which include multi-lane tolling, traffic information, Call & Response(C&R) and vehicle safety applications. And communication system architecture and radio access scheme are discussed to meet service requirements. The radio access technology will provide the new wireless communication capabilities, which has high mobility, low latency and V2V communication with L2-level handover.

1. INTRODUCTION

Smart Highway system is 10 years long-term project in Korea. It may be considered as a future ITS system which has “Smart road” and “Smart Car” and will be able to provide more reliable, more safe and convenient road than current highway system. At first, we will discuss on service requirement from the view of system operator and user. From both views, we will categorize 4 service areas which include multi-lane tolling, Call and Response (C&R), traffic information and safety. Secondly, we will discuss physical system architecture which consists of smart platform, road side equipment (RSE) and center and provides seamless information environments. Thirdly, radio access technology is discussed to meet main requirements, which has high mobility with 200 km/h, low latency and vehicle-to-vehicle (V2V) communication capability with L2 level handover. Finally, concluding remarks are summarized.

2. SERVICE REQUIREMENTS

Service concept can be derived by understanding system operators and users needs. We analyzed basic requirements from both sides. And system operator needs seamless information environments, which is able to monitor car and road status and send information in any time and any place. In other words, it means the car shall be always connected to the smart highway center. Seamless information environments will provide same benefits to users. But, users need terminal compatibility which provides inter-operability with existing urban traffic information system (UTIS) and dedicated short-range communications (DSRC) system. The basic service demands are as follows.

<Table 1> Service requirements from system operator and users

	System Operator	Users
Requirements	. Multi-lane tolling . Car status monitoring . Road status monitoring . Multimedia download . Call & Response (C&R) . Safety messaging . Location information . Traffic Information	. Call & Response . Multimedia download . Safety messaging . Traffic Information . DSRC interworking . UTIS interworking

As for the service demands, we also analyzed the requirements of communication aspects. In multi-lane tolling, we have to consider high mobility up to 200 km/h and high speed packet transmission up to 10 Mbps in spot area. In C&R application, we have to consider L2 level hand-over and relative large radio coverage up to 1 Km to provide seamless information environments. In safety message dissemination, we have to consider both V2V and vehicle-to-infrastructure (V2I) communication capability. By following that approach, basic communication requirements are summarized as shown in the table 2.

<Table 2> Communication requirements

Items	Communication Requirements
Communication Types	V2V, V2I & I2V suuport
Function	Unicast, Multi-casting, Broadcasting
Speed	Maximum 200 km/h
Range	Maximum 1 km
Information Types	Packet Data/Streaming/Image
Data Rate	Maximum 10 Mbps
Link Connection Time	100msec
PER(packet error rate)	Less than 10%
Hand Over	L2 level Hand Over

3. SYSTEM ARCHITECTURE

Smart Highway system has physical and logic infrastructure. Physical infrastructure means physical road and communication network. Also logical infrastructure means software which includes communication protocols, application related software. In this paper, we will discuss on communication system to provide physical communication infrastructure. Communication system

structure depends on the total amount of information to be transferred from car terminals to the control center via road side equipment (RSE). The total amount of information practically means radio channel capacity. We roughly estimated that the required radio channel capacity will be 60~70 Mbps if we assume that 400 users are uniformly distributed in 4 lanes and 1 km radio coverage condition, the users mainly sends short packet messages and video streaming data with low activity. Also we are using radio access technology like wireless access in vehicular environments (WAVE) system because WAVE meets the basic main features. From the view of information capacity, we need at least 3 radio channels in case of WAVE system. At this stage, we will assume that one channel is assigned for control channel and 2 radio channels are assigned for service channels.

The communication system basically consists of smart terminal (ST) and RSE and control center. Smart terminal provides service platform and radio access capability with hand-over. RSE will provide radio access and back-bone connection capability. And it may have local server which provides road status sensing. Control center will provide IPv6 based platform and application through IPv6 network.

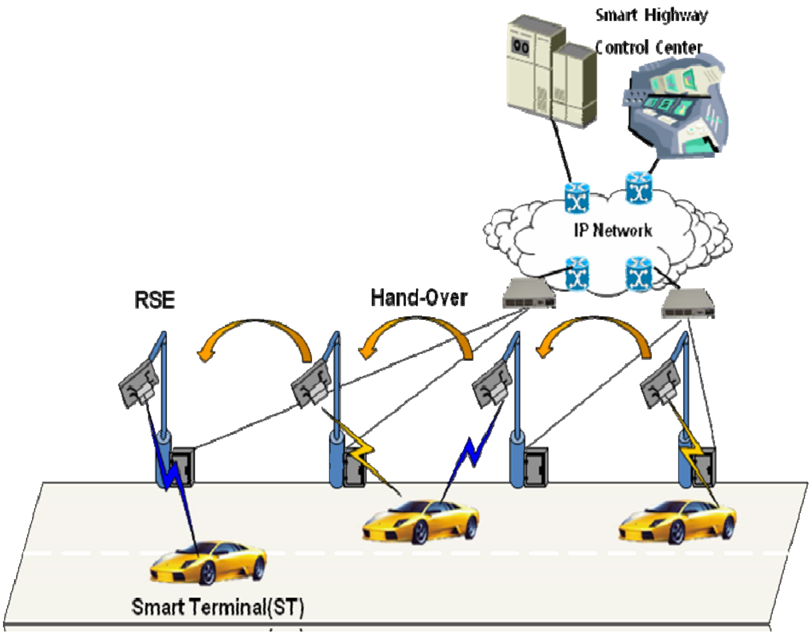

Fig. 1 Communication System for Smart Highway

4. RADIO ACCESS TECHNOLOGY

In this session, we compare radio access technologies for Smart Highway system, and handover scheme is introduced. Four radio access technologies which include wireless local area network (WLAN), WAVE, Wireless Broadband (WiBro) and DSRC are considered to establish seamless communication environments. We address the comparison of radio access technologies in terms of throughput, latency and communication scheme (V2V/V2I). Depending on radio access technologies, the comparison of throughput, latency and communication scheme is depicted in Fig. 2, 3 and 4,

respectively. Velocity is considered as a common factor. WLAN is designed to support low mobility, i.e., approximately 20km/h, and WiBro can support medium velocity. High mobility (up to 200km/h) can be supported by WAVE and DSRC. First, let us consider the throughput. As shown in Fig. 2, WLAN provides higher throughput than other technologies. However, low mobility makes it difficult to apply in high speed environment. WiBro and WAVE can support approximately 12Mbps. Since the DSRC is focused on the ETC, it requires low throughput compared with other technologies. In the viewpoint of latency, WAVE and DSRC have very short latency, i.e., 100msec, which can be applicable for the safety applications. Whereas, WiBro and WLAN relatively have long latency since their application mainly aims to internet service. Finally, let us consider the communication scheme. WAVE can support V2I/I2V as well as V2V communication as shown in Fig. 4. Other three technologies only adopt V2I or I2V communication.

Summarizing, we considered the radio access technologies in the three viewpoints. WAVE and DSRC can provide low latency with high mobility where the former has medium throughput and the later have low throughput. By using WLAN and WiBro, high throughput can be achieved, but they have long latency which prohibits safety applications from vehicular communications. Only WAVE support both V2I/I2V and V2V communications. Since each radio access technology has their own property, it is efficient to utilize all available technologies for adopting various scenarios, such as different traffic status, locations and data rates.

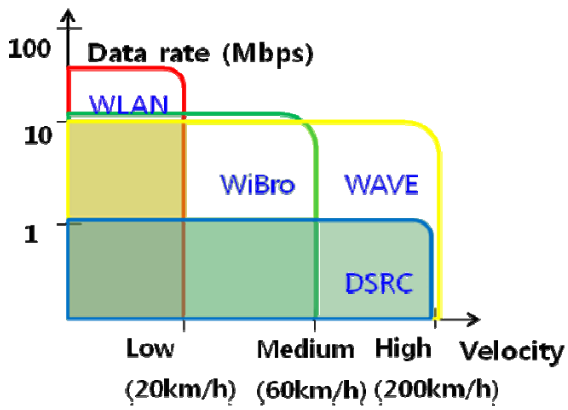

Fig. 2 Comparison of throughput (data rate) versus velocity

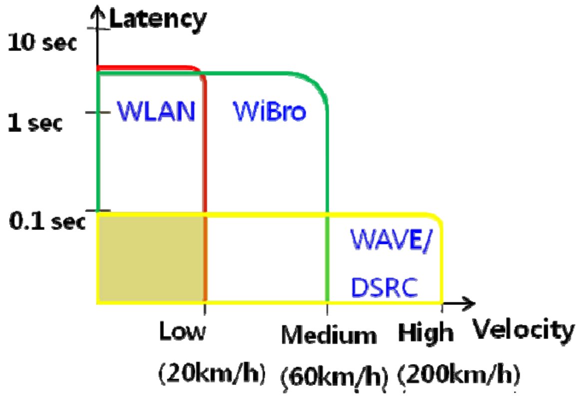

Fig. 3 Comparison of Latency versus velocity

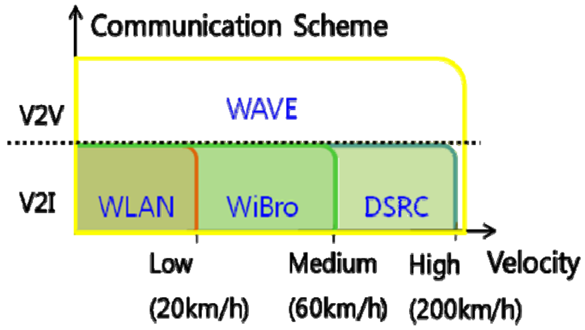

Fig. 4 Comparison of communication scheme versus velocity

In addition to radio access technologies, it is important to support L2 level handover for seamless communication environments in vehicular communications. The handover scheme in WLAN consists of three steps which are scanning, authentication and association. The handover time is mainly affected by the scanning procedure which detects access points because the scanning time takes long time. The several handover schemes to reduce the scanning time, have been proposed in the literatures. We suggest a new handover scheme suitable for Smart Highway. RSEs are aligned along the highway in Smart Highway. It means that the radio channel may predictable because the location of RSE is fixed and predetermined. This is distinct from the WLAN environments. This special environment enables us to predict the location and channel information of neighbor RSE. Therefore, the handover algorithm for Smart Highway has following properties:

- Time slot based beaconing and channel switching
- Fast scanning based on predetermined location information of RSE
- Beacon frame which contains neighbor RSE information
- Flexible beacon management based on neighbor RSE information

Based on above properties, we can carry out fast L2 level handover by dramatically reducing the

scanning time where this handover scheme supports individual C&R service.

5. CONCLUSIONS

Smart Highway system is a future ITS system which has “Smart road” and “Smart Car”. We analyzed the service and communication requirements. From those requirements, we discussed on communication system architecture, WAVE technology with L2-level handover will be able to provide C&R information environment for Smart Highway. Also we will have to do more research on hand-over algorithm to provide seamless information environment.

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